XXXVI.—*On the Muscular Anatomy of the Leg of the Crocodile.*

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[Plate XVI.]

During the Easter recess of 1864, I had an opportunity of explaining to Professor Gratiolet*, of Paris, the investigations I had made with respect to the mechanism of the leg of the Ostrich, and the theory I had formed to explain it. This distinguished anatomist did me the honour of approving of my explanation, and urged me to procure a Crocodile, in the posterior limb of which he assured me I should find a mechanical problem exceeding in complexity that presented by the leg of the Ostrich, and as yet unsolved by anatomists.

During the month of March last I was furnished with a young Crocodile from Egypt, by Mr. Thomas Moore, of Liverpool, to whom I had communicated my earnest desire to have an opportunity of dissecting such an animal; and the results of my examination fully bear out the anticipation of Prof. Gratiolet, and also furnish a complete confirmation of the principles I made use of in my theory of the leg of the Ostrich.

The interlacing of tendons in the hind leg of the Crocodile is very remarkable, and more complex than in the Ostrich, although in one respect it somewhat resembles it.

* The incalculable loss that science has sustained, in the early part of the present year, by the premature death of this distinguished anatomist is exceeded by the loss experienced by his friends, to whom his genial social qualities endeared him even more than his brilliant scientific attainments. I extract from the 'Journal des Débats' of the 19th of February 1865 the following just tribute to his memory:—

"Les sciences viennent de faire une perte aussi cruelle qu'imprévue : M. Gratiolet, professeur de zoologie à la Faculté des Sciences de Paris, a succombé hier matin à une attaque d'apoplexie.

"M. Gratiolet n'avait pas cinquante ans; avant hier, encore plein de vie et de santé, il travaillait à son laboratoire du Muséum d'Histoire Naturelle, lorsque, à deux heures, frappé d'une congestion subite, il dut être ramené à son domicile; quelques heures plus tard, il avait perdu connaissance; hier matin à quatre heures, il rendait le dernier soupir.

"Nous ne saurions peindre l'émotion profonde qu'a causée dans le monde scientifique l'annonce de cette mort prématurée. M. Gratiolet était aimé de tous; son affabilité, la droiture de son caractère, lui avaient concilié toutes les sympathies. Ses travaux d'anatomie comparée, ses recherches sur le système nerveux et sur le cerveau, etc., l'avaient mis au nombre des naturalistes les plus distingués de notre pays; son merveilleux talent d'élocution l'avait placé au premier rang parmi nos professeurs les plus renommés, et l'aptitude de son esprit pour les études métaphysiques avait imprimé à ses œuvres un caractère d'originalité qu'appréciaient les philosophes aussi bien que les savans.

"La mort est venue le frapper au moment où, après de longues années de lutte, il semblait sur le point de recueillir le fruit de ses laborieux efforts."

On removing the skin and dissecting away the fat, the muscles shown in Pl. XVI. fig. A are exposed.

1. M. glutæus maximus (*b*). Origin: from central half of the ilio-ischiadic line. Insertion: into the fascia outside and above the knee-joint. This is a broad flat muscle, and straps down the tendon of the rectus femoris in its passage over the knee. 0·15 oz.

2. M. rectus femoris (*a*). Origin: from anterior spine of ilium, close to the acetabulum. Insertion: as in leg of Ostrich, into a tendon passing over the knee, outwards, and terminating in a remarkable muscle* (*x*) in the calf of the leg, associated with the gastrocnemius (*u*), and deriving a second origin from the agitator caudæ (*c*), as shown in the figure. 0·08 oz.

3. M. agitator caudæ (*c*). Origin: from the ischiadic line, behind the glutæus maximus. Insertion: by a double tendon. (1) One tendon passes through a pulley on the outside of the knee, formed by the tendon of the biceps (*d*) as it passes to its fibular insertion, and is inserted in the head of the muscle (*x*) in the calf of the leg. (2) The second insertion is by means of a tendon that goes to the top and front of the tibia; this second tendon also serves to strap down the tendon of the rectus femoris (*a*). 0·03 oz.

4. M. biceps femoris (*d*). Origin: from the ilio-ischium, under and behind the origin of the glutæus maximus. Insertion: partly into the top of the fibula, forming a pulley for the agitator caudæ (*c*), and an additional strap for the rectus femoris (*a*), and partly, by means of another tendon, into the head of the peronæus longus (*y*). 0·05 oz.

5. M. semitendinosus (*e*). Origin: from the posterior point of the tuber ischii. Insertion: by a remarkable looped tendon having one end inserted into the back of lower end of femur, and the other end into the os calcis. 0·18 oz.

6. M. semimembranosus (*f*). Origin: tuber ischii. Insertion: into the top of the tibia, by a tendon common to this muscle and the gracilis. 0·11 oz.

The muscles of the calf, shown in the figure, are the following:—

7. M. gastrocnemius (*u*). This muscle, as usual, has an outer and inner head. 0·14 oz. *Outer head*:—Origin: from the tendon of the great caudal extensor of the thigh, half an inch from its insertion into the outer condyle. Insertion: into the under side of the outer tarsal bone (vide *a*, fig. B) and into the plantar fascia. 0·11 oz. *Inner head*:—Origin: from the top of fibula and inner condyle of femur. Insertion: by a tendon, which unites with that of the outer head before reaching the os calcis,

* This muscle may be the plantaris.

under which it passes to be inserted into the outer and under side of the outer tarsal bone. 0·03 oz.

8. M. plantaris ? (*x*). Origin, double: from rectus femoris and from agitator caudæ. Insertion: having become partially blended with the outer gastrocnemius, it is inserted into the os calcis and under surface of the plantar fascia. 0·04 oz.

9. M. peronæus longus (*y*). Origin: from the shaft of the fibula and from the tendon of the biceps femoris (*d*). Insertion: into the outer tarsal bone, uniting with the tendon of the gastrocnemius. 0·03 oz.

10. Mm. tibialis anticus and extensor digitorum communis. Insertion: into the tarsal ends of first, second, and third metatarsal bones. 0·11.

The interlacing of muscles in the thigh and leg of the Crocodile, just described, is very remarkable, and more complicated even than that found in the Ostrich; and at first I was disposed to think that it threw some doubt on the explanation I had given previously of the reason for such an arrangement in the bird's leg. In the case of the Ostrich, the necessity for strict simultaneity of action was made evident by the great force of the muscles employed, and the great delicacy of the bones on which they had to act. What could there be, in the case of the Crocodile, to correspond to such a peculiarity in the case of the Ostrich? After some careful dissection, I found the ready answer to my question in the remarkable muscle which I shall now describe.

On clearing away the superficial muscles of the thigh and tail, I found the enormous mass of muscle, figured at *b*, fig. B, Pl. XVI., which acts as the chief and powerful extensor of the thigh:—

11. M. extensor femoris caudalis* (*b*). Origin: from the transverse and inferior spinous processes of the caudal vertebræ, from the third to the fifteenth inclusive. Insertion: into the back of the upper part of the femur, and into a great round

* This remarkable muscle is noticed and accurately described by Meckel in tom. iii. p. 152, 153 of his 'System der vergleichenden Anatomie,' Halle, 1828; but it is very strange that he transposes its origin and insertion, and seems not to have had any idea of its real use. It is regarded from his point of view as a descriptive anatomist, and without the remotest reference to its final cause. He says, "Der zweite, tiefere, weit dickere Muskel ist von dem ersten [the superficial muscle of the tail] wie einer breiten Binde umgeben, entspringt mit zwei ganz getrennten; einer weit kürzern, breiten Sehne oben von den hintern Fläche des Oberschenkelbeines; durch eine weit längere, schlanke, unten zwischen den beiden Gelenkknorren desselben Knochens, und setzt sich an die ganze Seitenfläche der untern Dornen, so wie der Zwischendornenhaut und die untere Fläche der Wurzeln der Querfortsätze."

tendon, which receives, in particular, the anterior fibres of this enormous muscle, and, passing down the back of the femur, is inserted by a strong common aponeurosis into the outer condyle of the femur and into the head of the fibula. This common aponeurosis also gives a partial origin to the gastrocnemius (*a*, fig. B) and to the plantaris (*x*, fig. A). 1·81 oz.

There are two muscles, accessory to this great caudal extensor in their action, which are as follows:—

12. M. extensori femoris caudali accessorius. Origin: from the fascia covering the great caudal extensor, and by a tendinous head from the quadratus femoris, which is also an accessory to the great caudal. Insertion: into the looped tendon of the semimembranosus already described. 0·01 oz.

13. M. quadratus femoris. Origin: posterior, superior, and inner surface of the pubis, near its symphysis. Insertion: into the back of the femur, with the action and position of the quadratus femoris in mammal quadrupeds, and into the tendon of the great caudal extensor. 0·05 oz.

The effect of the interlacing of the tendons of the various muscles already described must be to produce simultaneity of action among them, such as I have already endeavoured to describe in my account of the leg of the Ostrich; and in the present instance of the Crocodile there seems to be a similar principle involved. The Crocodile, resting on mud, progresses chiefly by using his hind feet as paddles; and in this use of them the great caudal extensor of the thigh is the most powerful and important muscle employed. And it seems to me that the simultaneity of action of all parts of the leg, rendered necessary by the employment of so powerful a muscle, is fully secured by the interlacing of the tendons I have described, which renders it impossible for one set of muscles to act without the others being also exerted.

The remaining muscles of the posterior limb are as follows:—

14. M. glutæus medius. Origin: from the central part of the ilio-ischiadic surface. Insertion: its tendon passes over the great trochanter, to be inserted into a line down the upper half of the outside of the femur, between the origins of the two portions of the vastus externus. 0·06 oz.

15. M. glutæus minimus. Origin: from the anterior point of the ilium. Insertion: into the inner side of the knee, under the fascia of the rectus femoris. 0·02 oz.

16. Mm. vastus internus, externus, et cruræus. The vastus externus consists of two distinct muscles, as in the Ostrich. 0·22 oz.

17. M. psoas. This large muscle takes an origin as high as the last rib, and is inserted into the lesser trochanter and the

intertrochanteric line leading to the outer side of the femur. It lies outside the iliacus. 0·57 oz.

18. M. iliacus. Origin: from the anterior transverse surface of the ilium, with a slip from the spine. Insertion: altogether into the lesser trochanter. 0·11 oz.

19. M. sartorius. Origin: behind the origin of the rectus, on the inner side, at the junction of the ilium and marsupial bone. Insertion: into the fascia of the inner side of the thigh, for two-thirds of its length. 0·04 oz.

20. M. gracilis takes an origin from two heads, one at the posterior point of the pubis and the other on the pectineal line. Insertion: into the head of the tibia by a tendon common to it with the semimembranosus. 0·08 oz.

21. M. pectinæus. Origin: between the two heads of gracilis, from the central part of the surface of the pubis and from the pectineal line. Insertion: into the top of the linea aspera. 0·06 oz.

22. Mm. adductores. There are three adductor muscles:—

1st adductor. Origin: anterior pectineal line of pubis. Insertion: into the upper half of the linea aspera. 0·13 oz.

2nd adductor. Origin: from posterior edge of pubis, its middle third. Insertion: into the middle of the linea aspera. 0·03 oz.

3rd adductor. Origin: from the posterior edge of the pubis, close to the symphysis. Insertion: into the back of the top of the fibula, with a fascial union with the tendon of semitendinosus. 0·05 oz.

23. M. obturator externus? Origin: from the tuber ischii, the posterior edge of the ischium, and the obturator membrane. Insertion: an oblique line in the back of the femur, below the insertion of the quadratus femoris. 0·13 oz.

24. M. marsupialis externus. 0·07 oz.

25. M. marsupialis internus. 0·10 oz.

These two muscles take their origin respectively from the outer surface of the marsupial bone, and from its inner surface and the last abdominal rib; and they are inserted by a common tendon into the top of the posterior intertrochanteric line. Their action is to rotate the femur directly inwards.

26. M. flexor proprius hallucis. Origin: from the outer condyle of femur. Insertion: into the first, second, and third toes. 0·02 oz.

27. M. flexor digitorum communis. Origin: from the fibula and tibia. Insertion: into the first, second, and third toes. 0·05 oz.

28. M. tibialis posticus. This muscle is inserted into the tarsal ends of the first, second, and third metatarsal bones. 0·06 oz.

29. M. peronæo-calcancus. Origin: from lower part of shaft of the fibula. Insertion: into the upper surface of the calcaneum. 0·01 oz.

XXXVII.—*Observations on Raphides and other Crystals in Plants.*

By George Gulliver, F.R.S.

[Continued from p. 117.]

Vitaceæ and *Araliaceæ*.—In the last communication ('Annals' for Aug. 1865) it was stated that raphides abound in all the plants, therein specified, which I had examined of the order Vitaceæ, while every species of the allied or related orders, of which comparative examinations were made, proved to be devoid of this raphidian character. I have had an opportunity, through the courtesy of a botanical friend, of dissecting a dried fragment of the receptacle-stalk of that most curious plant, *Pterisanthes* (*Vitis Pterisanthes*, Mic., *β. borneensis*), a bit of the dried leaf-blade and fruit-shell of *Bersama abassynica*, Fresen., and a part of the dried leaf and flower of *Natalia lucens*, Hochst. (*Rhaganus lucens*, E. Meyer). To the same genus, I have been told, *Bersama abassynica* is referred by Hooker and Bentham.

Pterisanthes, like *Vitis*, *Cissus*, and *Leea*, abounds in true raphides and sphæraphides. The raphides of *Pterisanthes* are about $\frac{1}{400}$th of an inch long and $\frac{1}{10000}$ thick; the average diameter of the sphæraphides is $\frac{1}{1600}$th of an inch. The *Bersama* and *Natalia* are destitute of true raphides, but contain numerous crystal-prisms, about $\frac{1}{250}$th of an inch long and $\frac{1}{2280}$th thick. These may be well seen in the leaf and inner membrane of the fruit-shell of *Bersama*, and in the leaf, calyx, petals, and pedicel of *Natalia*. The prisms have four equal faces, and their ends slope off either from angle to angle or from face to face.

Thus species of all the genera adopted by Lindley under the order Vitaceæ—*Cissus*, *Vitis*, *Pterisanthes*, *Leea*, and *Rhaganus*—have now been examined, though too often in imperfect or unsatisfactory fragments; and in every one of these plants true raphides were found, except the *Bersama* and *Natalia* (*Rhaganus*), in which raphides are replaced by crystal-prisms. It may be recollected that a like phenomenon occurs in the last order (Roxburghiaceæ) of the raphidian class Dictyogenæ, as described in the 'Annals' for June 1865.

Of Araliaceæ and Vitaceæ, the comparative structure in the leaves and some other parts has already been described ('Annals' for August 1865). I have lately examined fresh leaves and twigs of *Aralia spinosa*, and a bit of a dried leaf-blade of *A. racemosa*.